Reconstruction of aortic blood flow pattern after thoracic stent graft implantation

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Introduction

Thoracic Endovascular Aortic Repair (TEVAR) of various aortic pathologies has turned out as attractive therapeutic alternative to conventional surgical approaches. TEVAR may be associated with graft related complications such as endoleaks, kinking, infolding, and stentgraft migration, disconformability and disattachment phenomena. Therefore a better understanding of the hemodynamic impact of the implanted stent appears important to get a better understanding of the related complications.

The objective of this work was to investigate the applicability of MRI to provide data for the temporally resolved three-dimensional reconstruction of the aortic flow pattern over the cardiac cycle.

Methods

Twelve consecutive patients (3 female, 9 male; mean age 38 +/- 18; 8 – 2417d after intervention) were enrolled in this feasibility study. All patients initially presented with aortic rupture at the transition zone of the arch and descending segment of the thoracic aorta. The rupture site was treated with endovascular stent graft procedures in all patients. In six patients, a Medtronic Valiant stent graft and in six patients a Gore excluder TAG stent graft were implanted. All patients underwent conventional contrast agent (CA) enhanced routine CTA followed by the investigational MRI protocol, comprising a three-dimensional angiogram of the aorta with and without contrast enhancement. Cardiac phase resolved three-dimensional phase contrast angiograms with three-dimensional flow encoding were acquired. Acquisition parameters were as: TE/TR = 3.1/5.3ms, 2.5x2.5x3mm³ spatial resolution, respiratory navigator, 15°flip angle, 200cm/s velocity encoding along AP, RL and FH direction.

Visualization of flow velocities, path lines reconstruction, and region-of-interest (ROI) analysis were performed with the GTFlow software (GyroTools, Switzerland). In order to measure the increase of peak flow velocities inside the stent, ROI's encompassing the entire aortic lumen were placed at several positions along the aortic arc. To visualize the flow path lines, seed points for the path integrations were placed at the level of the aortic root as well as in selected locations inside the stent.

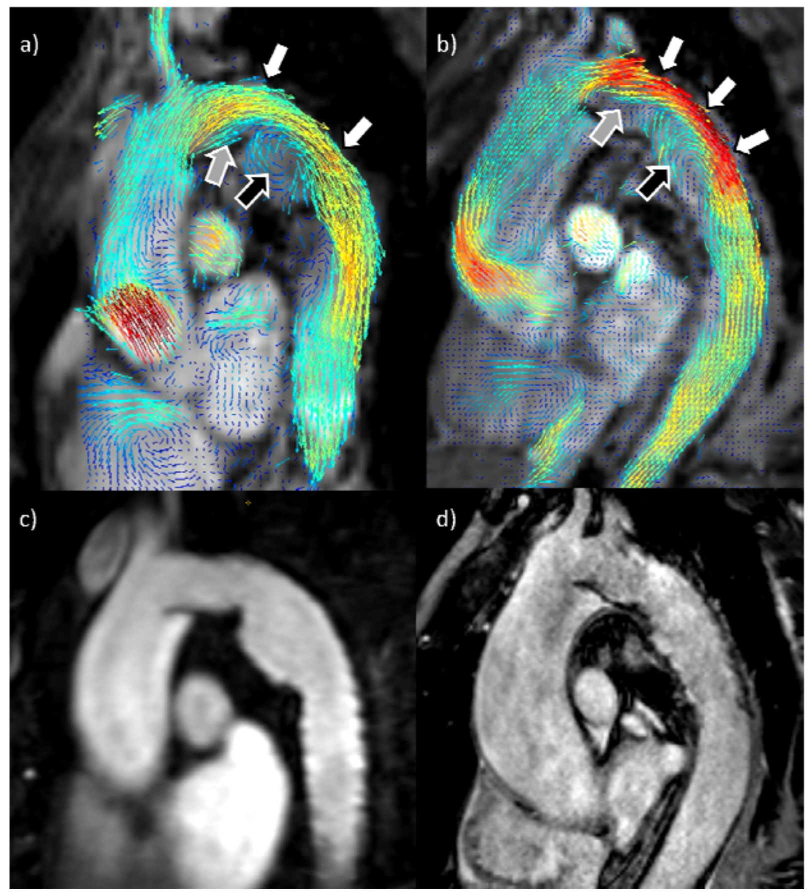

Figure 1: End-systolic snapshot (a,b) of the velocity pattern and the respective morphology (c,d). white arrows: accerated velocity; block arrows: circulating blood; gray arrows: reduced velocity

Results

The MRI imaging protocol could be completed in all patients. The average acquisition time for the entire MRI examination was 54 +/- 16 minutes. In all patients, the geometry of the stent graft, its dynamic and the three-dimensional cardiac phase resolved flow images could be obtained at sufficient quality for subsequent three-dimensional flow reconstruction. Fig. 1 shows exemplarily the reconstructed flow pattern and the respective morphology for two patients. Individual peak velocities and flow accelerations inside the stents varied widely amongst the patients. Depending on the deployment of the stent, peak velocities of up to 266.8 cm/s could be observed inside the stent. Furthermore, circulating blood at low velocity could be observed at the rupture site in 4 patients.

Discussion

MRI can be applied for the three-dimensional reconstruction of blood flow pattern after TEVAR. Areas of accelerated and reduced blood velocities as well as areas of circulating blood can be clearly identified. Whether the retrieved information can be applied for a better understanding of the TEVAR-related complications or even for an improved outcome prediction must be investigated in further clinical studies.

References: Markl, Michael et al, J Comput Assist Tomogr. 2004 Jul-Aug;28(4):459-68